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Infant Temperament, Maternal Personality, and Parenting Stress as Contributors to Infant Developmental Outcomes

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This study examined contributions of maternal personality and infant temperament to infant vocabulary and cognitive development both directly and indirectly through parental stress. Participants were recruited at birth and included 63 infant twin pairs and their mothers. Assessments were completed at 6, 9, 12, and 18 months of age and included Dimensions of Temperament–Revised (maternal personality), Parenting Stress Index (parental stress), Infant Behavior Questionnaire–Revised (infant temperament), Bayley Scales of Infant Development II: Mental Development Index, and MacArthur-Bates Total Vocabulary. Structural equation modeling with a jackknife approach was used to analyze data separately for each twin in the pair. At 12 months, maternal personality and infant temperament contributed indirectly to MacArthur-Bates Total Vocabulary and Bayley Mental Development Index scores through parental stress. In addition, infant temperament directly contributed to 12-month MacArthur-Bates Total Vocabulary. At 18 months, these relationships were no longer significant. The

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different findings at 12 months compared to 18 months may reflect important developmental and environmental shifts, as well as possible differences in the method and measurements used at each age.

Infant Temperament, Maternal Personality, and Parenting Stress as Contributors to Infant Developmental Outcomes

Children's learning in preschool and beyond is predicated, in part, on the skills they have acquired in infancy and toddlerhood (Blair, 2002). Indeed, the extent to which young children acquire early cognitive skills has been associated with certain early behaviors, termed *learning-related* or *work-related behaviors.* These include attention, self-regulation, inhibition, and cooperation, and have been found to be relatively stable characteristics in young children. Both maternal personality and infant temperament have been implicated as contributors to children's early cognitive outcomes. Specifically, precursors of the types of behaviors that appear to influence preschool learning (i.e., learning-related behaviors) have been studied for decades in infant temperament research (Kagan, 1994; Rothbart, 1989; Rothbart & Derryberry, 1981; Thomas & Chess, 1977). Research also indicates that maternal warmth and flexibility in parenting are positively associated with children's cognitive outcomes (Smith, Landry, & Swank, 2000).

In addition, both infant temperament and maternal personality are associated with parents' perceptions of stress, such that mothers with infants with more difficult temperaments and mothers' with more negative personalities report more stress. Research suggests links between mothers' attributions of behaviors in children and perceptions of children's academic and social functioning (Korat, 2004; Miller, 1986). Indeed, maternal perceptions of the child are associated with the experiences and opportunities that mothers provide for the child and these, in turn, may influence child cognitive outcomes (Bornstein, Tamis-LeMonda, & Haynes 1999; Feldman, Eidelman, & Rotenberg, 2004; Korat, 2004; Lemelin, Tarabulsy, & Provost, 2006) and child behaviors (Lengua & Kovacs, 2005). Therefore, the purpose of the present study was to understand how maternal perceptions of infant temperament, maternal personality, and family functioning (i.e., parental stress) are related to infant cognitive skills.

Infant Temperament

Temperament reflects behavioral and physiological systems and the processes that serve to modulate these systems (Rothbart & Bates, 2006). A number of studies describe temperament as reflecting actions and reactions that are evident early in life (DiLalla & Jones, 2000; Posner & Rothbart,

2000). The temperaments of infants have been found to develop and differentiate over time, which reflect changes in the underlying systems that occur with development, experience, and heredity (Rothbart, Derryberry, & Hershey, 2000). Temperament is multidimensional; some dimensions include approach/withdrawal, inhibition, attention, activity, distress, and soothability. Infants with "difficult" temperaments are high in activity, distress, and withdrawal (Bates, 1983).

Infant temperament has been reported to influence later adjustment to and performance in preschool and kindergarten. Salley and Dixon (2007) report that vocabulary at 21 months of age is positively correlated with positive components of temperament, such as executive controls (attention, inhibition) and surgency/extroversion, and negatively correlated with negative components, such as affect (frustration, sadness). Congruent with this, Lemelin et al. (2006) studied temperament of infants at 15 and 18 months, and performance on the Bayley Scales of Infant Development II (BSID-II): Mental Development Index (MDI) (Bayley, 1993) at 6–10 months. Activity level (an indicator of emotional arousal) predicted performance on the MDI, with lower activity scores predicting higher cognitive scores. The temperament characteristic of *activity* has been found to be related to cognitive skills differently, depending on when it is measured. DiLalla et al. (1990) reported a positive relation between activity measured at 9 months and cognitive skills, whereas Lemelin et al. (2006) reported a negative correlation when activity was measured at 15–18 months. Early activity may reflect the engagement of infants with their environment that may, in turn, engage parents and other caregivers in interactions with the infants, whereas high activity at later ages may hinder productive engagement with the environment or with engaging caregivers in that environment.

Investigations of relations between child temperament and parental perceptions of their children's cognitive skills support the idea that parents' reports of stress are related to their perceptions of their children's skills and the nature of their interactions with them (Chaffee, Cunningham, Secord-Gilbert, Elbard, & Richards, 1991). Research studies comparing parental perceptions of children's cognitive skills with independent assessments of the same or similar skills reveal both matches and mismatches in the accuracy of parental perceptions (Korat, 2004). Noel, Peterson, and Jesso (2008) linked children's temperament at 2–4 years of age with expressive vocabulary measures and found low levels of emotionality (intensity and arousal) and parenting stress correlated with higher vocabulary scores. These authors reason that the easier temperaments and lower parenting stress may serve to engage parents in more social interaction with their infants.

Maternal Personality

A mother's ability to adapt characteristics of her personality, such as warm responsiveness or restrictiveness, to her child's current and changing developmental needs has been found to influence children's cognitive outcomes (Smith et al., 2000). Landry, Smith, Miller-Loncar, and Swank (1997) found children whose mothers were more approachable and flexible in their interactions had greater growth in cognitive and language skills between 6 and 40 months of age. Magill-Evans and Harrison (1999) reported that higher maternal responsiveness resulted in higher Bayley MDI scores at 18 months on the BSID-II (Bayley, 1993). Further, the ability of a mother and child to interact with each other was related to maternal ratings of children's receptive and expressive language, as well as measured performance on the Bayley MDI (Markus, Mundy, Morales, Delgado, & Yale, 2000). Olson, Bayles, and Bates (1986) reported that the frequency of responsive mother-child language interactions was linked with mothers' assessments of their children's vocabularies at 13 and 24 months. Similarly, Bornstein et al. (1999) found that the vocabulary skills of infants at 20 months were related to increases in their mothers' verbal responsiveness between 13 and 20 months. Infants' vocabulary development between 13 and 20 months was predictive of mothers' responsiveness. These are transactional relations in which mothers and infants shape and are shaped by their experiences with each other.

Maternal personality is associated with children's socioemotional outcomes, as well. Specifically, maternal expressiveness is related to children's socioemotional development (Laible, 2006). Moreover, maternal parenting factors (e.g., chaos in the home, maternal feelings, and maternal discipline) predicted preschool children's problem behaviors such as hyperactivity, and emotional, peer, and conduct problems (Pike, Iervolino, Eley, Price, & Plomin, 2006). Some studies have reported that difficult or irritable infants have mothers who are less responsive or less stimulating, but other research has not supported these findings. For example, maternal ratings of temperament at 6 months were not related to maternal behavior in feeding interactions (Zeanah, Keener, & Anders, 1986). Crockenberg (1986) summarized several studies of older infants in which mothers of difficult or irritable infants were found to be *more* (rather than less) engaged with their infants than were mothers of easy or less irritable infants. Crockenberg suggested that relationships between maternal perceptions of infant temperament and maternal behaviors are complex, and highlighted the importance of considering the role of maternal personality in these relationships.

Parenting skills also influence maternal *interactions with* and *perceptions of* children. For example, mothers with negative parenting attitudes were more withdrawn and rated their infants at 6 months of age as more difficult and were less sensitive to their infants at 12–15 months (Kiang, Moreno, & Robinson, 2004). Furthermore, mothers who experienced depressive symptoms and viewed their infants as difficult were at an increased risk of displaying hostile-reactive parenting behaviors (Boivin et al., 2005). Even mild levels of parental distress influence parental perceptions of child behavior, such that parents with mild depressive symptoms report their infants as having more emotion regulation and attention problems. Parents with mild anxiety symptoms reported more distractibility and social problems and less soothability in their preschool children than did parents without depressive symptoms (West & Newman, 2003). Thus, the parenting process is influenced by parent personality that, in turn, affects both maternal interactions with and perceptions of the child.

Stress

The first 3 years of life are especially critical for the potential impact of stress in the parenting system on a child's cognitive, emotional, and behavioral development (Burke & Abidin, 1980). Physical and psychological stresses may affect the quality of interactions between mothers and infants. Mothers who are stressed have less positive feelings about their infants and are less able than other mothers to perceive and respond to behavioral cues from their infants (Crnic, Greenberg, Ragozin, Robinson, & Basham, 1983). Parents who experience high levels of stress display lower levels of positive emotion and have negative perceptions of their child's behavior (Adams, 2006; Middlebrook & Forehand, 1985).

Infants who have "difficult" temperaments may exacerbate this stress. Coplan, Bowker, and Cooper (2003) found evidence for a bidirectional relationship between infant temperament and parental stress. That is, mothers of infants with "difficult" temperaments reported more parenting problems, such that child temperament affected parental stress, and parental stress affected child temperament. Belsky (1984) viewed temperament as a critical component influencing the process of parenting, where the temperament characteristics of children may be related to the types of parenting they experience. Indeed, Belsky, Bakermans-Kranenburg, and van Ijzendoorn (2007) report children are "differentially susceptible" to the influences of the quality of parenting style and child-rearing experiences. Children with difficult temperaments (e.g., negative emotionality, low adaptability, low regulation) who experienced harsh or nonsupportive

parenting showed more negative behaviors than did children with less difficult temperaments.

The Current Study

To study the combined contributions of maternal personality, infant temperament, and parenting stress, we recruited families with infant twins. Such a study has a number of advantages. First, although the birth of an infant increases stress in all families, the birth of twin infants magnifies the stress. The demands on parental time are greater for two infants because more time is needed for physical care and practical tasks, and less time may be available for the formation of parent-child relationships (Lytton, Conway, & Sauve, 1977; Robin, Josse, & Tourrette, 1988). In addition, there may be discordance between the two infants in patterns of sleeping, feeding, and crying, resulting in more fatigue and stress for the parents (Thorpe, Golding, MacGillivray, & Greenwood, 1991). Parents may feel guilty and become emotionally frustrated when attending to one infant while the other infant is making demands on attention (Becker, 1986; Thorpe et al, 1991). This series of physical and psychological stresses may affect the quality of interaction between parents and infants. Thus, the contributions of maternal personality and infant temperament to infant outcomes in the context of parental stress are particularly salient with families of twins.

Second, data the study of from twin infants offer the opportunity, by using data from more than one sample, to test the model that posits that maternal personality, infant temperament, and parent stress influence infant developmental outcomes. Data from one randomly selected infant of each twin pair can be used to test the fit of the model, and then model fit statistics can be compared against those obtained when the model is tested by using data from the comparison twin. Congruent with Belsky's (1984) view of family functioning, mothers' interactions with and perceptions of each infant might be different because of infants' characteristics. In addition, the influence of family functioning, particularly parenting stress level, on child outcomes, and the extent to which these relationships are stable across development, can be tested by comparing models using a selected infant and a comparison infant.

Finally, there may be differences between maternal reports of infant development and objective assessments of it. A component of the present study is how infant developmental outcomes based on maternal reports are influenced by maternal personality, perceptions of infant temperament, and family stress compared to outcome measures based on direct assessment administered by a research team. Two measures reported to be valid

indicators of infant development are the MacArthur-Bates Communicative Development Inventory (Fenson et al., 1992), which is a maternal report measure of early language development, and the Bayley MDI, a standardized assessment of early cognitive abilities. Reports from studies using both measures confirm that language scores on the MacArthur-Bates positively correlated with scores on the Bayley MDI at 14 months ($r = 0.33$, $p < 0.001$) and ($r = 0.50$, $p < 0.001$) at 18 months ($r = 0.50$, $p < 0.001$) with a sample of Finnish infants, providing evidence of some comparability between these measures of infants' development (Lyytinen, Laakso, Poikkeus, & Rita, 1999).

This study examines the influence of three dimensions of maternal personality (Rigidity/Flexibility, Approach/Withdrawal, and Mood), three dimensions of infant temperament (Distress, Withdrawal, and Activity), and mothers' reports of parenting stress on measures of infant developmental outcomes. Figures 1 and 2 show the hypothesized relations between these variables. Specifically, in this study we ask the following questions: (a) To what extent do infant temperament and maternal personality *directly* contribute to maternal perceptions of their infants' vocabulary acquisition at 12 and 18 months? (b) To what extent do infant temperament and maternal personality *indirectly* contribute to maternal perceptions of their infants' vocabulary acquisition at 12 and 18 months through their contributions to maternal reports of parenting stress? (c) To what extent do infant temperament and maternal personality *directly* contribute to infants' measured cognitive ability at 12 and 18 months? (d) To what extent do infant temperament and maternal personality *indirectly* contribute to infants' measured cognitive ability at 12 and 18 months through their contributions to maternal reports of parenting stress?

Method

Participants

The infants in this study were participants in a longitudinal study of maternal and twin infant interactions. The participants were recruited at birth from families willing to participate, who expected to be available for follow-up testing sessions through age 18 months, and whose twin infants did not have complications that were likely to result in permanent cognitive impairments (e.g., intraventricular hemorrhage, severe and persisting respiratory distress, CNS or metabolic complications likely to be chronic, or genetic abnormalities). Data on study variables were obtained for 63 twin pairs (monozygous [MZ] = 18 total, 13 male/male and 5 female/female;

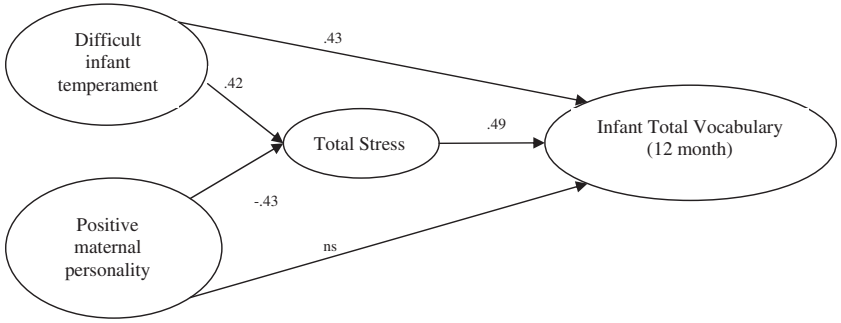

Figure 1a. Parameter estimates for predicting MacArthur-Bates Total Vocabulary at 12 months (Model 1).

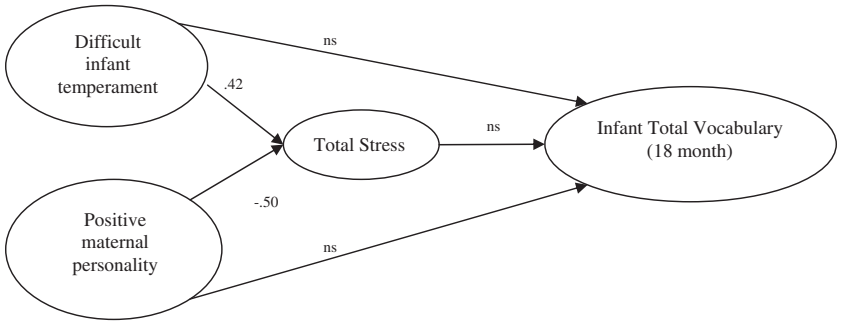

Figure 1b. Parameter estimates for predicting MacArthur-Bates Total Vocabulary at 18 months (Model 2).

dizygous [DZ] = 44 total, 8 male/male, 13 female/female and 23 male/female). Zygosity was based on DNA tests of infants at birth, but DNA results for 1 female-female twin pair were not obtained. Descriptive statistics on gestational age, birth weight, and 5–minute Apgar scores (Apgar, 1953) are in Table 1.

The mothers ranged in age from 15 to 37 years, (M = 28.62 years, *SD* = 4.77), and they reported 0–3 previous births (*M* = 0.73, *SD* = 0.92). Shipley (1991) IQ scores of the mothers ranged from 75 to 124 (M = 110.87, *SD* = 7.85). Information was obtained from parents to compute a family socioeconomic status (SES) score using education, occupation, and total family income. All three indicators were based on a 7-point scale (*1 = lowest, 7 = highest*). Where data for both mother and father were available, the highest level of education and occupation was selected. Education level ranged

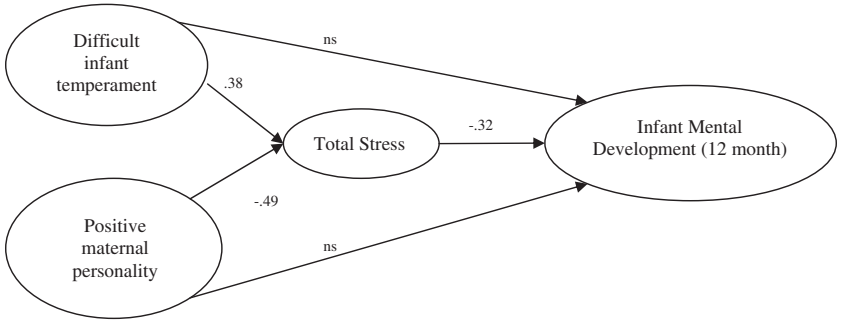

Figure 2a. Parameter estimates for predicting Bayley MDI at 12 months (Model 3).

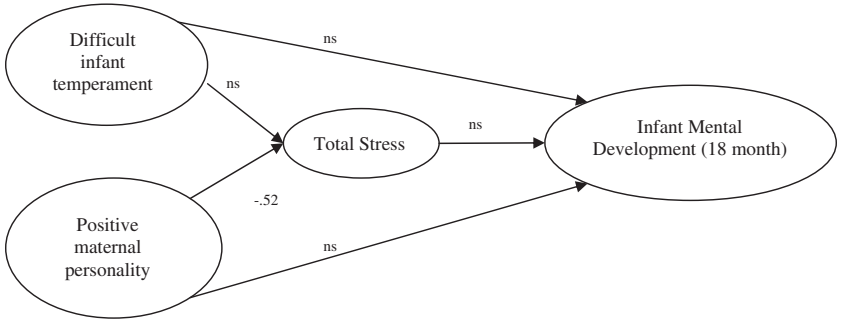

Figure 2b. Parameter estimates for predicting infant Bayley MDI at 18 months (Model 4).

from 1 = completed eighth grade to 7 = more than 5 years of college. Parental occupation was scored using a version of the Hollingshead (Bonjean, Hill, & McLemore, 1967) scheme with updated occupational categories in which more current occupations and occupation titles have been added. Family income ranged from 1 = less than $5,000 to 7 = more than $45,000. For three families, SES was calculated using education alone, and for one family, SES was calculated with education and occupation. Descriptive statistics are in Table 2.

Measures

Two measures of infant cognitive skills were obtained: one administered during infants' laboratory visits, and one reported by mothers. These results of the measures are shown in Table 1. The Bayley MDI of the BSID-II

Table 1. Descriptive Statistics for the Twin Infant Sample ($N = 63$ Twin Pairs)

	Total Group			Selected			Comparison		
Infants	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
Gestational age (weeks)	34.95	3.08	26–39	34.95	3.08	26–39	34.95	3.08	26–39
Birth weight (grams)	2,277.56	648.20	510–3,572	2,295.85	653	510–3,543	2,259.27	648.23	850–3,572
Apgar: 5 minutes	8.67	0.77	5–10	8.66	0.70	5–9	8.68	0.76	5–10
Bayley MDI									
12 Months	84.4	10.01	61–112	83.64	9.95	62–112	85.16	10.09	61–107
18 Months	82.2	13.14	55–117	81.15	13.69	55–117	83.25	12.61	59–111
MacArthur-Bates Total Vocabulary									
12 Months	51.67	63.62	0–393	51.83	68.31	2–393	51.51	59.11	0–287
18 Months	162.23	78.37	16–396	161.16	79.03	19–396	163.29	78.47	16–396
Infant Behavior Questionnaire									
Withdrawal	2.58	0.82	1.00–4.92	2.55	0.83	1.00–4.92	2.62	0.82	1.00–4.67
Distress	3.48	0.84	1.74–5.80	3.62	0.85	1.74–5.80	3.35	0.81	1.95–4.90
Activity	4.37	0.75	2.63–5.94	4.42	0.79	2.63–5.94	4.33	0.71	2.88–5.94

Table 2. Descriptive Statistics for the Parental Sample (N = 63)

Mothers	M	SD	Range
Age (N = 63)	28.62	4.77	15–37
Socioeconomic status	5.13	1.58	1–7
Education	4.82	1.82	1–7
Occupation	4.90	1.62	1–7
Income	6.12	1.60	1–7
Shipley IQ (N = 61)	110.87	7.85	75–124
Dimensions of temperament (N = 58)			
Approach/withdrawal	20.28	3.68	11–27
Flexibility/rigidity	15.21	3.72	9–20
Mood	24.62	3.50	14–28
Parental Stress Index			
6 Months (N = 59)	213.07	33.13	139–295
9 Months (N = 55)	209.51	33.30	131–297
12 Months (N = 54)	211.23	35.74	141–309
18 Months (N = 51)	215.87	40.54	148–398

was used to assess infant general cognitive abilities at 12 and 18 months. The 12-and 18-month Bayley MDI includes items to assess perception, problem solving, number concepts, language, and personal/social abilities. According to the examiner's manual (Bayley, 1993), the Bayley MDI is appropriate for children from 1 to 42 months, with a test-retest reliability of .83. Raw scores were converted into standardized MDI scores.

The MacArthur-Bates Communicative Development Inventory (Fenson et al., 1992) is a parent report measure of early language development that can be used with infants who are 8 to 18 months of age. The inventory scales include Early Words, and Actions and Gestures. In this study, mothers reported the Early Words of their infants at 12 and 18 months that involved reporting vocabulary (e.g., animal names, toys, food and drink, body parts). The vocabulary items are separated into those words that the infant understands and those that the infant understands and says. MacArthur-Bates Total Vocabulary raw scores were used in the analyses reported here. The MacArthur-Bates Total Vocabulary raw score is composed of "understands" and "understands and says," and scored as 0 = does not understand or says, and 1 = understands or says. The manual reports a

Cronbach's alpha of .95 for comprehension and .96 for production (Fenson et al., 1992). The Cronbach's alpha for MacArthur-Bates Total Vocabulary for the present study was .99 at 12 and 18 months.

On these measures, the scores were not adjusted for prematurity. The use of adjusted scores is controversial because of differences of opinion on how much adjustment should be made (e.g., scores based on conceptual age versus chronological age or a midpoint) (Wilson & Cradock, 2004), how long such adjustments should be made (e.g., up to age 1 or age 2 or longer) (Siegel, 1983), and how prematurity and low birth weight influence decisions to adjust scores (Aylward, 1994). However, it makes sense in a study seeking to understand how the behaviors of infants contribute to their mothers' reports of stress and developmental concerns to use unadjusted scores.

Infant temperament. The Infant Behavior Questionnaire (IBQ) (Rothbart, 1981, 1986) was used to assess infant temperament through maternal reports when infants were 12 months old. Each item pertains to the infant's typical behavior over a variety of situations (e.g., During feeding, how often did the baby squirm or kick? During sleep, how often did the baby toss about in the crib?) and is scored on a 7-point scale (*1 = never to 7 = always*). Scores reflect the mothers' judgments of the frequency of a specific behavior during the previous week or, for some items, during the past 2 weeks. Exploratory factor analysis with promax rotation (SPSS version 16.0, 2008) was used to examine the factor structure of the IBQ subscales with our data. We found strong support for a two-factor solution: Positive Emotionality and Negative Emotionality. For the purposes of our study, we used the Negative Emotionality factor, which was made up of scores from the activity level, distress to limitations, and withdrawal subscales. In this study, the Cronbach's alpha values for infant behavior at 12 months were activity level, .81; distress, .87; and withdrawal, .79.

Maternal personality. The Dimensions of Temperament Survey–Revised (DOTS-R) (Windle & Lerner, 1986) is a questionnaire designed to measure features of personality from early childhood to early adulthood. The DOTS-R was completed by mothers when infants were 9 months old. The 54 questions are scored on a 1–4 scale (*1 = usually false, 4 = usually true*), and scores are combined to form summary scores describing activity level (e.g., general, sleep), approach/withdrawal, flexibility/rigidity, mood, rhythmicity (e.g., sleep, eating, daily habits), distractibility, and persistence. Exploratory factor analysis (principal axis factoring with promax rotation) (SPSS, 2008) pointed to a three-factor solution: Rhythmicity, Persistence/Focus, and Affect. In this study, we used the Affect factor, made up of scores from the approach/withdrawal, flexibility/rigidity, and mood

subscales. The Cronbach's alphas for these subscales with the current sample were approach/withdrawal, .72; flexibility/rigidity, .80; and mood, .87.

Maternal stress. The Parenting Stress Index (PSI) (Abidin, 1990; Burke & Abidin, 1980; Loyd & Abidin, 1985) is a 120-item multiple-choice questionnaire designed to assess parent-child stresses that may lead to dysfunctional behaviors for the parent or problems for the child. Parents rated their children's behavior (e.g., My child is always hanging on me) or their own feelings (e.g., I often have the feeling that I cannot handle things very well) on a 5-point Likert-type scale (*1= strongly agree, 5= strongly disagree*). Stressors include domains of child characteristics and behavior, mother characteristics, and situational/demographic variables. Specific sources of stress include areas such as the degree of adaptability of the child, the child's reinforcing qualities, the infant's degree of demandingness, the child's activity level, the parent's subjective feeling of being trapped by parenting responsibilities, social isolation, subjective feelings of attachment to child, and spousal and social system support. The parent and child domains are combined for a Total Stress score. The examiner's manual reports a 6-month interval test-retest reliability of .84. The Total Stress scores from the PSI completed at 6, 9, and 12 months were used in analyses with outcomes at 12 months, and the PSI completed at 9, 12, and 18 months were used in analyses of outcomes at 18 months.

Procedure

The University of Louisville Internal Review Board approved the study protocol. Initial recruitment of participants began at their birth, and infant testing was conducted subsequently at 3-to 6-month intervals. At 6, 12, and 18 months, the parents brought the infants to the laboratory for assessments. Trained personnel assessed infants on the Bayley MDI at the laboratory visits. Mothers were mailed packets of questionnaires (e.g., the PSI, IBQ, and MacArthur-Bates) and brought completed forms or completed the forms during the laboratory visits. When the infants were 9 months old, mothers were mailed the DOTS-R scale and the PSI to complete and return by mail.

Analysis

Twins were divided into two groups (i.e., Selected and Comparison) for analyses. One member of each of the 63 twin pairs was randomly selected for inclusion in the Selected group, and the other twin was designated for the Comparison group, with one exception: one Selected twin did not have

complete data on all variables and was exchanged with the Comparison twin. After grouping, *t* tests were used to determine whether significant differences within the Selected and Comparison groups on outcome variables existed based on zygosity or gender. The results of the zygosity analyses showed no differences between MZ or DZ infants within the Selected group and within the Comparison group on any of the outcome measures at 12 and 18 months. Additionally, no significant differences between male or female infants on any of the outcome measures at 12 and 18 months were found within the Selected group or within the Comparison group. Multivariate analyses of variance were conducted to examine the extent to which gender, zygosity, and SES contributed to infants' scores on the MacArthur-Bates Total Vocabulary or Bayley MDI at 12 or 18 months. Results showed no differences among gender, zygosity, and socioeconomic groups (using both total family income and maternal education) on infants' scores.

Raw score data were analyzed by using Analysis of Moment Structures 6.0 (AMOS) (Arbuckle, 2007) software and structural equation modeling (SEM). SEM was chosen as an optimal data analysis technique for two reasons. First, it allows for the construction of latent variables with multiple observed variables while accounting for measurement error. Second, SEM produces fit indices giving an estimate of the stability of the model for very similar samples (Byrne, 2001). Thus, SEM was used to test the fit of the model by using data for the Selected group and then to test the tenability of the model by examining its fit with the Comparison group. Since we had incomplete data for 12 twin pairs, we used maximum likelihood estimation that is robust to missing data points.

To answer our research questions, we proposed four models (i.e., one model for each outcome variable). In each model, paths were drawn from difficult infant temperament (i.e., Negative Emotionality, measured with observed IBQ scores on withdrawal, distress to limitations, and activity) and positive maternal personality (i.e., Affect, measured with observed DOTS-R scores on approach/withdrawal, flexibility/rigidity, and mood) to maternal stress (measured with observed PSI scores for stress; at 12 months, PSIs at 6, 9, and 12 months were used; at 18 months, PSIs at 9, 12, and 18 months were used) and infant outcomes measured with a different observed variable for each model (i.e., Model 1: MacArthur-Bates Total Vocabulary at 12 months; Model 2: MacArthur-Bates Total Vocabulary at 18 months; Model 3: Bayley MDI at 12 months; Model 4: Bayley MDI at 18 months). In addition, a path was drawn from maternal stress to the infant outcome.

Our proposed models of relationships among maternal personality, infant temperament, maternal stress, and infant outcomes at 12 and 18

months were tested in multiple steps. Although our Selected and Comparison samples were small for each analysis ($N = 63$), we were able to test the stability of the models by multigroup analysis. First, baseline models were run with no between-group constraints. These models are used to test for equivalence across groups when additional cross-group constraints are imposed. Then, a series of chi-square tests were conducted comparing the baseline (i.e., unconstrained) model to subsequent models with increasing numbers of constraints. The constraints were applied in the following order: measurement weights, measurement intercepts, structural weights, structural covariances, structural residuals, and measurement residuals. If the chi-square change between the baseline (unconstrained) model and the final model with all cross-group constraints imposed is not statistically significant, then equivalence between groups is supported. According to Byrne (2001), invariance between groups means that the groups should be analyzed together. However, because our data were infants nested in families, the lack of independence dictated that we keep the groups separate.

For each model, we first report results from the multigroup analyses. Second, we report parameter estimates for the Selected group from the unconstrained (i.e., baseline) model. The following fit statistics were reported for the unconstrained models: Comparative Fit Index (CFI; values close to 1 indicate very good fit), Incremental Fit Index (IFI; values close to 1 indicate very good fit), and Root Mean Square Error of Approximation (RMSEA; values close to 0 indicate very good fit) (Byrne, 2001).

Results

Descriptive analyses were conducted on the outcome measures. The means and standard deviations (listed in Table 1) reflect differences in score variation for the MacArthur-Bates Total Vocabulary and Bayley MDI scores. For example, the standard deviation for the Bayley MDI at 12 months was 10.01, whereas the standard deviation for the MacArthur-Bates Total Vocabulary at 12 months was 63.62. Similarly, the Bayley MDI at 18 months was 13.14, whereas the standard deviation for the MacArthur-Bates Total Vocabulary at 18 months was 78.37. This variability suggests greater error in the estimates of infants' total vocabulary acquisition (MacArthur-Bates Total Vocabulary) than in estimates of infants' cognitive skills (Bayley MDI).

Pearson correlation analyses showed generally low correlations among variables included in this study. Although some correlation coefficients were statistically significant, none was greater than .24. Correlations were moderate between MacArthur-Bates Total Vocabulary scores at 12 and 18

months (r = .485, p < .01), and between Bayley MDI scores at 12 and 18 months (r = .400, p < .01). On the other hand, correlations between MacArthur-Bates Total Vocabulary and Bayley MDI scores were low at 12 and 18 months (.105 and .217, respectively). The correlations between infant outcomes with temperament and parental stress are listed in Table 3.

Maternal Report of Total Vocabulary

Our first set of analyses focused on MacArthur-Bates Total Vocabulary scores, which are the mothers' reports of their children's vocabulary at 12 (Model 1) and 18 (Model 2) months. We examined the direct paths from maternal personality and infant temperament to infant vocabulary, and indirect paths from maternal personality and infant temperament to infant vocabulary through maternal reports of stress (both concurrent with the report of infant vocabulary and at two times prior). The tested models are shown in Figures 1a and 1b.

MacArthur-Bates Total Vocabulary at 12 months. Multigroup analyses indicate that Model 1 (Figure 1a) was stable across the Selected and Comparison groups of twins ($\chi\Delta^2_{\text{unconstrained}}$ = 66.409, df = 64; $\chi^2_{\text{fully constrained}}$ = 83.729, df = 98; $\chi^2\Delta_{34}$ = 17.32, *ns*). Indeed, parameter estimates for the models across all cross-group constraint conditions were similar. Fit statistics suggest very good fit between the model and the data: CFI = .975, IFI = .978, RMSEA = .031. See Table 4 for chi-square statistics and goodness-of-fit indices for unconstrained and fully constrained models.

Results show a statistically significant direct path between infant temperament and MacArthur-Bates Total Vocabulary (β = .43, p = .032), such that an infant's more "difficult" temperament (i.e., higher activity, more distress to limitations, and more withdrawal) contributed to more MacArthur-Bates Total Vocabulary acquisition by 12 months. In addition, a statistically significant indirect path between infant temperament and MacArthur-Bates Total Vocabulary emerged through mothers' reports of stress over time (6, 9, and 12 months). Specifically, infant temperament predicted stress (β = .423, p = .01), and stress predicted MacArthur-Bates Total Vocabulary acquisition, at 12 months (β = .485, p = .017), indicating that more "difficult" infant temperament predicted higher maternal reports of stress over time, and higher stress predicted more MacArthur-Bates Total Vocabulary. In addition, a direct, negative path between maternal personality and stress (β = –.434, p = .03) was found, suggesting that a positive maternal personality (i.e., less withdrawal, less rigidity, positive mood) predicted maternal reports of lower stress over time. There was not a statistically significant direct path from maternal personality to MacArthur-Bates Total Vocabulary.

Table 3. Correlations of Infant Outcomes with Temperament and Parental Stress

	Bayley Mental Development Index		MacArthur-Bates Total Vocabulary	
	12 Months	18 Months	12 Months	18 Months
Infant behavior Questionnaire				
Withdrawal	–0.041	0.008	0.183	0.097
Distress	0.063	–0.040	0.174	–0.048
Activity	–0.083	0.179	0.208*	0.050
Dimensions of temperament				
Approach/withdrawal	–0.018	–0.071	0.118	0.237*
Flexibility/rigidity	0.086	0.051	–0.176	0.025
Activity	–0.007	0.241*	0.097	0.210*
Parental Stress Index				
6 Months	–0.193*	–0.195*	–0.131	–0.092
9 Months	–0.108	–0.165	–0.221*	–0.150
12 Months	–0.192	–0.055	–0.238*	–0.282**
18 Months	–0.117	–0.220*	–0.152	–0.155

*$p < .05$; **$p < .01$.

Table 4. Summary of Tests of Invariance between Selected and Comparison Twin Groups

	$\chi 2$	$\chi^2\Delta$	*df*	IFI	CFI	RMSEA
Model 1: 12-Month MacArthur-Bates Total Vocabulary						
Unconstrained	74.746	NA	67	1.044	.975	.031
Fully constrained	83.729	17.32	98	.978	1.000	.00
Model 2: 18-Month MacArthur-Bates Total Vocabulary						
Unconstrained	59.271	NA	62	1.070	1.0	.00
Fully constrained	76.387	17.116	96	1.009	1.0	.00
Model 3: 12-Month Bayley MDI						
Unconstrained	66.049	NA	64	1.086	1.0	.00
Fully constrained	83.729	17.32	98	1.020	1.0	.00
Model 4: 18-Month Bayley MDI						
Unconstrained	166.972	NA	62	.678	.617	.114
Fully constrained	187.858	20.866	98	.673	.662	.087

CFI = Comparative Fit Index, IFI = Incremental Fit Index, MDI = Mental Development Index, NA = not applicable, RMSEA = Root Mean Square Error of Approximation.

MacArthur-Bates Total Vocabulary at 18 months. Multigroup analyses indicate that Model 2 (Figure 1b) was stable across the Selected and Comparison groups of twins ($\chi^2_{\text{unconstrained}} = 59.271$, $df = 62$; $\chi^2_{\text{fully constrained}} = 76.387$, $df = 96$; $\chi^2\Delta_{34} = 17.116$, *ns*). Parameter estimates for the models across all cross-group constraint conditions were similar. Fit statistics suggest very good fit between the model and the data: CFI = 1.0, IFI = 1.009, RMSEA = .0. See Table 4 for chi-square statistics and goodness-of-fit indices for unconstrained and fully constrained models.

Results show statistically significant paths between infant temperament and stress ($\beta = .424$, $p = .008$), such that an infant's more "difficult" temperament (i.e., higher activity, more distress to limitations, and more withdrawal) contributed to lower stress as reported by mothers over time (9, 12, and 18 months). Similarly, a statistically significant path emerged between maternal personality and stress ($\beta = -.503$, $p = .013$), where a positive maternal personality (i.e., less withdrawal, less rigidity, positive mood) contributed to maternal reports of less stress over time. There were no statistically significant links from infant temperament, maternal personality, or stress to infant MacArthur-Bates Total Vocabulary at 18 months.

Bayley MDI Scores

Our next set of analyses focused on Bayley MDI scores. We examined the direct paths from maternal personality and infant temperament to Bayley MDI at age 12 months (Model 3) and 18 months (Model 4), and indirect paths from maternal personality and infant temperament to Bayley MDI through maternal reports of stress (both concurrent with the test of Bayley MDI and twice prior). The tested models are shown in Figure 2a and b.

Bayley MDI scores at 12 months. Multigroup analyses indicate that Model 3 (Figure 2a) was stable across the Selected and Comparison groups of twins ($\chi^2_{\text{unconstrained}} = 66.409$, $df = 64$; $\chi^2_{\text{fully constrained}} = 83.729$, $df = 98$; $\chi^2\Delta_{34} = 17.32$, *ns*). Indeed, parameter estimates for the models across all cross-group constraint conditions were similar. Fit statistics suggest very good fit between the model and the data: CFI = 1.0, IFI = 1.02, RMSEA = .0. See Table 4 for chi-square statistics and goodness-of-fit indices for unconstrained and fully constrained models.

Statistically significant indirect paths between infant temperament and Bayley MDI at 12 months, and between maternal personality and Bayley MDI at 12 months, emerged through mothers' reports of stress over time (6, 9, and 12 months). Specifically, infant temperament ($\beta = .38$, $p = .017$) and maternal personality ($\beta = -.448$, $p = .024$) contributed to maternal stress, and maternal stress contributed to Bayley MDI at 12 months ($\beta = -.322$, $p = .10$). These results indicate that less "difficult" infant temperament (i.e., lower activity, less distress to limitations, more approach) contributed to maternal reports of lower stress, positive maternal personality (i.e., less withdrawal, less rigidity, positive mood) contributed to lower maternal stress, and lower stress contributed to higher Bayley MDI scores. Direct paths from infant temperament and maternal personality to MDI at 12 months were nonsignificant.

Bayley MDI scores at 18 months. Multigroup analyses indicate that Model 4 (Figure 2b) was stable across the Selected and Comparison groups of twins ($\chi^2_{\text{unconstrained}} = 166.972$, $df = 64$; $\chi^2_{\text{fully constrained}} = 187.858$, $df = 98$; $\chi^2\Delta_{34} = 20.866$, *ns*). Indeed, parameter estimates for the models across all cross-group constraint conditions were similar. Fit statistics suggest poor fit between the model and the data: CFI = .617, IFI = .673, RMSEA = .114. See Table 4 for chi-square statistics and goodness-of-fit indices for unconstrained and fully constrained models.

In this model, the only statistically significant path was that from maternal personality to maternal stress ($\beta = -.522$, $p = .034$). With this path, positive maternal personality (i.e., less withdrawal, less rigidity, positive mood) contributed to lower stress. There were no other statistically

significant links from infant temperament, maternal personality, or stress to Bayley MDI at 18 months.

Summary of Results

In predicting scores on both MacArthur-Bates Total Vocabulary (assessed by mothers) and Bayley MDI (assessed by researchers) at 12 and 18 months, our models show positive maternal personality was directly linked to lower maternal stress. Other findings varied depending on the age at which the outcomes were measured (12 or 18 months) and the type of outcome (MacArthur-Bates Total Vocabulary or Bayley MDI). In terms of age, no additional findings emerged for predicting MacArthur-Bates Total Vocabulary or Bayley MDI for infants at age 18 months. Regarding the type of outcome, a more difficult infant temperament predicted higher MacArthur-Bates Total Vocabulary scores at 12 months both directly and indirectly through increased maternal stress. On the other hand, for Bayley MDI scores, a more difficult infant temperament contributed to lower scores at 12 months indirectly, such that more difficult temperament contributed to more stress, and more stress contributed to lower cognitive scores.

Discussion

The results of this study support hypothesized relations among maternal personality, maternal perceptions of infant temperament, and parental stress, as well as provide some evidence that these variables contribute to perceived and measured assessments of children's cognitive skills. The relations between the variables under study were particularly evident at 12 months of age, where both maternal personality and infant temperament influenced parental stress and these, in turn, influenced mothers' perceptions of infants' vocabulary acquisition (MacArthur-Bates Total Vocabulary) and measured cognitive skill (Bayley MDI). It is noteworthy that the directions of these associations differed depending on the outcome variable (i.e., MacArthur-Bates Total Vocabulary or Bayley MDI). Mothers with fewer positive personality traits (i.e., less flexibility, lower approach, less positive mood), and who perceived their infants' temperament as more difficult (i.e., higher activity level, more distress, more withdrawal), reported higher levels of parenting stress and more vocabulary acquisition by their infants. However, these mothers had infants with *lower* Bayley MDI scores. At 18 months, links among maternal personality, infant temperament, and parenting stress were still found, but these variables were not related either to vocabulary or to cognitive skills scores.

The findings at 12 months are consistent with the view that maternal personality and infant temperament characteristics influence the parenting environment, as reflected in the reports of parenting stress in the current study, and are related to the polarities (positive or negative) of maternal personality and infant temperament that are present. That is, mothers with more positive personalities reported less stress, and mothers who rated their infants as less difficult reported less stress. Belsky and colleagues (1984, 2007) have argued that variables such as these influence children's parenting experiences, and these early experiences between mothers and infants are important for the growth of cognitive skills, as well as the growth of social behaviors. In view of Belsky et al., the outcomes for all children, and especially those who are *vulnerable* because of their "difficult" temperaments, are susceptible to the quality of parenting in their rearing environments. Our findings show maternal personality contributed to children's cognitive skills both directly and indirectly through the levels of parenting stress. It is important to reiterate that our findings relating more difficult infant temperament to more stress, and more stress to poorer infant outcomes, emerged for Bayley MDI scores (observed) but not MacArthur-Bates Total Vocabulary scores (mother report).

Our finding that mothers' assessments of more difficult infant temperament were related to infants' higher MacArthur-Bates Total Vocabulary scores at 12 months is inconsistent with some literature linking children's learning and work-related behaviors to academic outcomes (Finn, Pannozzo, & Voelkl, 1995; Lerner, Lerner, & Zabski, 1985; Martin & Holbrook, 1985). Research has shown, for example, that children who display less withdrawal, less activity, more attentiveness, and more effortful control are likely to achieve more academic success in preschool and primary grades (Alexander, Entwisle, & Dauber, 1993; Finn et al., 1995; Lerner et al., 1985; Martin & Holbrook, 1985; Palisin, 1986; Veldman & Worsham, 1983). However, we found infants assessed at 12 months as having higher activity levels, greater distress to limitations, and more withdrawal were rated by their mothers as having high MacArthur-Bates Total Vocabulary scores at 12 months. This was not the case for children's cognitive scores as measured by the Bayley MDI, though, where difficult infant temperament and maternal stress were associated with lower MDI scores.

There are two possible explanations for these findings, and both stem from the fact that the MacArthur-Bates Total Vocabulary score was based on *mothers'* perceptions, whereas children's Bayley MDI scores were independent of mothers' perceptions. First, children who are more "difficult" temperamentally are likely to receive more attention from their mothers, and this may *promote* vocabulary acquisition resulting from more

interactions between mothers and infants. Indeed, robust evidence points to the importance of language interactions, particularly syntactically complex interactions, to children's language development in the first 3 years of life (Hart & Risley, 1995; Huttenlocher, Vasilyeva, & Cymerman, 2002; Weizman & Snow, 2001). For cognitive scores, our findings are similar to those reported by Lemelin et al. (2006), who explained their finding of low Bayley MDI scores associated with higher infant activity level as reflecting differential attention by these infants to aspects of the environment that influence cognitive development. In our study, the "difficult temperament" construct is composed of three dimensions (higher activity, more distress to limitations, and more withdrawal), and these temperament characteristics may work against engagement with the environment. A second, related explanation is also based on the possibility that more "difficult" infants receive more attention from mothers. Mothers' focused attention on their infants might promote greater awareness of their infants' vocabulary acquisition, resulting in the reporting of higher MacArthur-Bates Total Vocabulary scores. But a "difficult" temperament may work against engagement in a Bayley MDI assessment that involves "on demand" task performance. Difficult infants may perform less well in that assessment situation than do "easy infants," who are easily engaged in tasks.

We also found that maternal personality, infant temperament, and parenting stress predicted outcome measures only when infants were 12 months of age. For infants at 18 months of age, the variables under study were not linked with either perceived vocabulary (MacArthur-Bates Total Vocabulary) or measured cognitive skill (Bayley MDI) outcomes as they had been for infants at 12 months of age. This is likely an artifact of major environmental and developmental shifts that occur between 12 and 18 months. Important changes in children's environments clearly occur with age. For decades, researchers and theorists have described the differential effects of the child's environment according to how directly environmental variables influence the child (Bradley, 1993; Bronfenbrenner, 1986; Molfese, DiLalla, & Bunce, 1997). Proximal variables are those that are experienced directly by the child, such as parenting practices, characteristics of the home, and child-centered daily activities. SES, parents' own rearing experiences in childhood, and their developmental histories are classified as distal variables because these are experienced by the child only indirectly or from a distance. The influence of proximal and distal variables on cognitive skills has been found to change as children age (e.g., Molfese et al., 1997), such that proximal variables are particularly strong in the early years, but become less so in later years when distal variables, particularly SES, become stronger. In the present study, the influence of

maternal personality, infant temperament, and parenting stress on 18-month outcomes may reflect the changing influence of proximal and distal variables because infants' environments typically broaden with more experiences outside the home, additional caregivers, and interactions with other infants and children.

This environmental shift is related to the substantial developmental shift that occurs between 12 and 18 months. There is evidence of a spurt in vocabulary acquisition in reports by Fenson et al. (1992), based on the standardization sample for MacArthur-Bates scores, as well as by other investigators (e.g., Fernald, Swingley, & Pinto, 2001). Explanations for a spurt are varied and sometimes controversial (McMurray, 2007). For example, although MacArthur-Bates Total Vocabulary scores at 12 months are based on parents' perceptions of the number of words their infants understand and at 18 months are based on the words infants understand and say, scores at 12 months clearly include more parent conjecture than at 18 months because of the typical shift in expressive vocabulary skills between these age points. When considered in the context of a "difficult" temperament, it may be that parents ascribe *more* vocabulary understanding to their children (thus increasing bias in perception) in their desire to alleviate the stress of parenting through more effective communication.

Others have justified findings of a vocabulary burst during these age points based on changes in cognitive skills that facilitate word learning, such as automaticity and working memory (Mills, Plunkett, Prat, & Schafer, 2005), "fast mapping" (i.e., acquiring vocabulary with minimal exposure) (Gershkoff-Stowe & Hahn, 2007), or "mutual exclusivity" (i.e., vocabulary development based on narrow category definitions) (Markman, Wasow, & Hansen, 2003), and that these mechanisms are facilitated with the expansion of children's environments and experiences. Further research that includes more measures of proximal and distal variables is needed to study how changes in these variables influence differences in fit between the models tested with 12-month outcomes compared to the models with 18-month outcomes.

Differences between the fit of the data to the models at 12 and 18 months may also reflect the changes in cognitive skills growth observed during that age span. Fischer and Bidell (2006) have discussed continuities and discontinuities in the patterns of growth in cognitive skills as related to variability in the construction of skill "webs" in which different domains of skills are developing at progressively complex levels within individuals. Others report that changes in brain development in infancy are related to changes in skills (Bell, 1998; Wolfe & Bell, 2007), particularly at sites in the cortex (Thatcher, 1994). The basis of the continuities and

discontinuities in this age range are not well understood, but findings from twin studies point to a strong genetic influence on cognitive skills (Patrick, 2000). Taken together, this evidence suggests that infant development is complex, occurring at different rates within and between individuals. Thus, pinpointing specific maternal personality, infant temperament, and parenting stress variables that predict cognitive outcomes at both 12 and 18 months is difficult.

An important strength of our study was the use of a jackknife approach in which data were analyzed separately for each twin in a twin pair. This resulted in two groups for analysis (i.e., Selected and Comparison), enabling us to test the stability and tenability of our models across *both* groups. Because we found that the models were invariant across groups, we could have confidence in our findings, and the fit of our models with the data, despite our relatively small sample size. Although we had anticipated that the mothers' interactions with and perceptions of each infant might be different because of the infants' characteristics, the good model fit across groups suggests that there was commonality between infants for these infant twin pairs. The findings might, therefore, reflect the contribution of genetic influences on cognitive skills found in studies comparing infant twin pairs, as well as the shared environment variables, investigated extensively in behavior genetic studies (for a review, see Patrick, 2000).

Limitations

Two limitations warrant mention. First, associations found among variables in this study may be due in part to all the predictor variables, as well as one outcome variable (MacArthur-Bates Total Vocabulary), for this study being based on maternal report. Even so, there is substantial evidence that mothers are good reporters of their child's skills and their own behaviors (Rothbart & Bates, 2006). Given their vantage point as observers of their children in a variety of contexts and over time, it makes sense that maternal report measures of the variables under study are valuable. It is important to note, however, that the correlation between MacArthur-Bates Total Vocabulary and Bayley MDI scores was low in this study, which could be due to method differences (mother report versus objective assessment by laboratory personnel) or measurement differences (an assessment of language skills versus an assessment of an array of cognitive skills). The differences in variability found for MacArthur-Bates Total Vocabulary scores compared to the Bayley MDI underscore the possible method and measurement differences in the outcome measures that could have resulted in greater error in the estimates of infants' total vocabulary acquisition

(MacArthur-Bates Total Vocabulary) than in estimates of infants' cognitive skills (Bayley MDI). Further study of a possible developmental shift in vocabulary and cognitive skills, and the influence of temperament, personality, and parenting stress, should use a better balance of parental report measures and objectively administered measures.

The sample also is relatively homogeneous in terms of SES. The education, occupation, and total family income of the sample were well above average, which may limit the generalizability of the findings. Future replication of the results is needed with a larger, more diverse population.

Conclusion

These findings have implications for practice and research. Our finding that difficult infant temperament as perceived by mothers was predictive of stress and of vocabulary and cognitive outcomes at 12 months suggests that certain temperament characteristics in infancy may bode well for children's eventual learning. At the same time, the direction of these associations varies depending on the type of cognitive outcome, with difficult temperament related to higher vocabulary scores and less difficult temperament related to higher Bayley MDI scores. These complex findings suggest that more work should be done to better understand the mechanism by which infant temperament relates to positive cognitive outcomes.

The findings provide evidence that, in infancy, the characteristics that have been studied as "learning" and "work related" behavior in preschoolers are important predictors of academic success in preschool and early elementary grades (McClelland, Morrison, & Holmes, 2000). These findings can inform practitioners and parents of the early indicators of possible risk and protective factors for children's learning and achievement (Sanson, Oberklaid, Pedlow, & Prior, 1991). The more limited findings from the models tested for 18-month outcomes are disappointing and suggest that additional variables or measures that target more specific outcomes might be needed. Future research should explore not only the proximal variables we have included but also more of the distal variables (e.g., daycare experiences, number of caregivers, and measures of the number of caregiver interactions with the infant/child) that may influence outcomes in later infancy and early childhood as environments and experiences broaden. Future research should also explore more of the complexities of vocabulary development (e.g., word classes and frequencies of words in the language) and other skill domains known to support vocabulary development (e.g., memory span, and interpersonal behaviors involving joint attention).

References

Abidin, R. R. (1990). *Parenting Stress Index.* Charlottesville, VA: Pediatric Psychology Press.

Adams, K. L. (2006). Parental stress, parenting behavior, and observed parent-child interaction (Doctoral dissertation, Pace University, 2006). *Dissertation Abstracts International, 66,* 118.

Alexander, K. L., Entwisle, D. R., & Dauber, S. L. (1993). First-grade classroom behavior: Its short-and long-term consequences for school performance. *Child Development, 64,* 801–814.

Apgar, V. (1953). A proposal for a new method of evaluation of the newborn infant. *Anesthesia and Analgesia: Current Research, 32,* 260–267.

Arbuckle, J. L. (2007). *AMOS 6.0 update to the AMOS user's guide.* Chicago: Smallwaters.

Aylward, G. (1994). *Practitioner's guide to developmental and psychological testing.* New York: Plenum.

Bates, J. E. (1983). Issues in the assessment of difficult temperament: A reply to Thomas, Chess, & Korn. *Merrill-Palmer Quarterly, 29,* 89–97.

Bayley, N. (1993). *Bayley Scales of Infant Development* (2nd ed.). San Antonio, TX: Psychological Corporation.

Becker, P. G. (1986). Counseling families with twins: Birth to 3 years of age. *Pediatrics in Review, 8,* 81–86.

Bell, M. A. (1998). The ontogeny of the EEG during infancy and childhood: Implications for cognitive development. In B. Garreau (Ed.), *Neuroimaging in child psychiatric disorders* (pp. 97–111). Berlin: Springer-Verlag.

Belsky, J. (1984). The determinants of parenting: A process model. *Child Development, 55,* 83–96.

Belsky, J., Bakermans-Kranenburg, M., & van Ijzendoorn, M. (2007). For better and for worse: Differential susceptibility to environmental influences. *Current Directions in Psychological Science, 16,* 300–304.

Blair, C. (2002). School readiness: Integrating cognition and emotion in a neurobiological conceptualization of children's functioning at school entry. *American Psychologist, 57,* 111–127.

Boivin, M., Perusse, D., Dionne, G., Saysset, V., Zoccolillo, M., Tarabulsy, G. M., et al. (2005). The genetic-environmental etiology of parents' perceptions and self-assessed behaviours toward their 5-month-old infants in a large twin and singleton sample. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 46,* 612–630.

Bonjean, C., Hill, R., & McLemore, S. (1967). *Sociological measurement: An inventory of scales and indices.* San Francisco: Chandler.

Bornstein, M., Tamis-LeMonda, H., & Haynes, M. (1999). First words in the

second year: Continuity, stability, and models of concurrent and predictive correspondence in vocabulary and verbal responsiveness across age and context. *Infant Behavior and Development, 22,* 65–85.

Bradley, R. (1993). Children's home environments, health, behavior, and intervention efforts: A review using the HOME inventory as a marker measure. *Genetic, Social, and General Psychology Monographs, 119,* 439–490.

Bronfenbrenner, U. (1986). Ecology of the family as a context for human development: Research perspectives. *Developmental Psychology, 22,* 723–742.

Burke, W. T., & Abidin, R. R. (1980). Parenting stress index (PSI): A family system assessment approach. In R. R. Abidin (Ed.), *Parenting education and intervention handbook* (pp. 516–527). Springfield, IL: Charles C. Thomas.

Byrne, B. M. (2001). *Structural equation modeling with AMOS.* Mahwah, NJ: Erlbaum.

Chaffee, C. A., Cunningham, C. E., Secord-Gilbert, M., Elbard, H., & Richards, J. (1991). The influence of parenting stress and child behavior problems on parental estimates of expressive and receptive language development. *Journal of Abnormal Child Psychology, 19,* 65–74.

Coplan, R. J., Bowker, A., & Cooper, S. M. (2003). Parenting daily hassles, child temperament, and social adjustment in preschool. *Early Childhood Research Quarterly, 18,* 376–395.

Crnic, K. A., Greenberg, M. T., Ragozin, A. S., Robinson, N. M., & Basham, R. B. (1983). Effects of stress and social support on mothers and premature and full-term infants. *Child Development, 54,* 209–217.

Crockenberg, S. (1986). Are temperamental differences in babies associated with predictable differences in caregiving? In J. V. Lerner & R. M. Lerner (Eds.), *Temperament and psychosocial interaction in childhood* (pp. 53–73). San Francisco: Jossey-Bass.

DiLalla, L. F., & Jones, S. (2000). Genetic and environmental influences on temperament in preschoolers. In D. L. Molfese & V. J. Molfese (Eds.), *Temperament and personality development across the life span* (pp. 33–55). Mahwah, NJ: Erlbaum.

DiLalla, L., Thompson, L., Plomin, R., Phillips, K., Fagan, J., Haith, M., et al. (1990). Infant predictors of preschool and adult IQ: A study of infant twins and their parents. *Developmental Psychology, 26,* 759–769.

Feldman, R., Eidelman, A. I., & Rotenberg, N. (2004). Parenting stress, infant emotion regulation, maternal sensitivity, and the cognitive development of triplets: A model for parent and child influences in a unique ecology. *Child Development, 75,* 1774–1791.

Fenson, L., Dale, P. S., Reznick, J. S., Thal, D., Bates, E., Harters, J. P., et al. (1992). *The MacArthur-Bates communicative development inventory: User's guide and technical manual.* San Diego, CA: Singular.

Fernald, A., Swingley, D., & Pinto, J. (2001). When half a word is enough: Infants can recognize spoken words using partial phonetic information. *Child Development, 72,* 1003–1015.

Finn, J. D., Pannozzo, G. M., & Voelkl, K. E. (1995). Disruptive and inattentive-withdrawn behavior and achievement among fourth graders. *Elementary School Journal, 95,* 421–434.

Fischer, K. W., & Bidell, T. R. (2006). Dynamic development of action, thought, and emotion. In R. M. Lerner (Ed.) & W. Damon (Series Ed.), *Handbook of child psychology: Vol. 1, Theoretical models of human development* (6th ed., pp. 313–339). New York: Wiley.

Gershkoff-Stowe, L., & Hahn, E. (2007). Fast mapping skills in the developing lexicon. *Journal of Speech, Language, and Hearing Research, 50,* 682–697.

Hart, B., & Risley, T. (1995). *Meaningful differences in the everyday experiences of young American children.* Baltimore: Paul H. Brookes.

Huttenlocher, J., Vasilyeva, M., & Cymerman, E. (2002). Language input and child syntax. *Cognitive Psychology, 45,* 337–374.

Kagan, J. (1994). *Galen's prophecy: Temperament in human nature.* New York: Basic Books.

Kiang, L., Moreno, A. J., & Robinson, J. L. (2004). Maternal preconceptions about parenting predict child temperament, maternal sensitivity, and children's empathy. *Developmental Psychology, 40,* 1081–1092.

Korat, O. (2004). Mothers' and teachers' attributions of the academic functioning of Israeli second graders: A comparison between social groups. *Early Childhood Research Quarterly, 19,* 485–501.

Laible, D. (2006). Maternal emotional expressiveness and attachment security: Links to representations of relationships and social behavior. *Merrill-Palmer Quarterly, 52,* 645–670.

Landry, S. H., Smith, K. E., Miller-Loncar, C. L., & Swank, P. R. (1997). Predicting cognitive-language and social growth curves from early maternal behaviors in children at varying degrees of biological risk. *Developmental Psychology, 33,* 1040–1053.

Lemelin, J., Tarabulsy, G. M., & Provost, M. A. (2006). Predicting preschool cognitive development from infant temperament, maternal sensitivity, and psychosocial risk. *Merrill-Palmer Quarterly, 52,* 779–806.

Lengua, L. J., & Kovacs, E. A. (2005). Bidirectional associations between temperament and parenting and the prediction of adjustment problems in middle childhood. *Applied Developmental Psychology, 26,* 21–38.

Lerner, J. V., Lerner, R. M., & Zabski, S. (1985). Temperament and elementary school children's actual and rated academic performance: A test of a "goodness-of-fit" model. *Journal of Child Psychology and Psychiatry, 26,* 125–136.

Loyd, B. H., & Abidin, R. R. (1985). Revision of the Parenting Stress Index. *Journal of Pediatric Psychology, 10,* 169–177.

Lytton, H., Conway, D., & Sauve, R. (1977). The impact of twinship on parent-child interaction. *Journal of Personality and Social Psychology, 35,* 97–107.

Lyytinen, P., Laakso, M., Poikkeus, A., & Rita, N. (1999). The development and predictive relations of play and language across the second year. *Scandinavian Journal of Psychology, 40,* 177–186.

Magill-Evans, J., & Harrison, M. J. (1999). Parent-child interactions and development of toddlers born preterm. *Western Journal of Nursing Research, 21,* 292–312.

Markman, E., Wasow, J., & Hansen, M. (2003). Use of the mutual exclusivity assumption by young word learners. *Cognitive Psychology, 47,* 241–275.

Markus, J., Mundy, P., Morales, M., Delgado, C. E. F., & Yale, M. (2000). Individual differences in infant skills as predictors of child-caregiver joint attention and language. *Social Development, 9,* 302–315.

Martin, R. P., & Holbrook, J. (1985). Relationship of temperament characteristics to the academic achievement of first-grade children. *Journal of Psychoeducational Assessment, 3,* 131–140.

McClelland, M. M., Morrison, F. J., & Holmes, D. L. (2000). Children at risk for early academic problems: The role of learning-related social skills. *Early Childhood Research Quarterly, 15,* 307–329.

McMurray, B. (2007). Defusing the childhood vocabulary explosion. *Science, 3,* 631.

Middlebrook, J. L., & Forehand, R. (1985). Maternal perceptions of deviance in child behavior as a function of stress and clinic versus nonclinic status of the child: An analogue study. *Behavior Therapy, 16,* 494–502.

Miller, S. A. (1986). Parent's beliefs about their children's cognitive abilities. *Developmental Psychology, 22,* 276–284.

Mills, D. L., Plunkett, K., Prat, C., & Schafer, G. (2005). Watching the infant brain learn words: Effects of vocabulary size and experience. *Cognitive Development, 20,* 19–31

Molfese, V., DiLalla, L., & Bunce, D. (1997). Prediction of the intelligence scores of 3-to 8-year-old children by home environment, socioeconomic status, and biomedical risks. *Merrill-Palmer Quarterly, 43,* 219–234.

Noel, M., Peterson, C., & Jesso, B. (2008). The relationship of parenting stress and child temperament to language development among economically disadvantaged preschoolers. *Journal of Child Language, 35,* 823–843.

Olson, S. L., Bayles, K., & Bates, J. E. (1986). Mother-child interaction and children's speech progress: A longitudinal study of the first two years. *Merrill-Palmer Quarterly, 32,* 1–20.

Palisin, H. (1986). Preschool temperament and performance on achievement tests. *Developmental Psychology, 22,* 766–770.

Patrick, C. (2000). Genetic and environmental influences on the development of cognitive abilities evidence from the field of developmental behavior genetics. *Journal of School Psychology, 38,* 79–108.

Pike, A., Iervolino, A. C., Eley, T. C., Price, T. S., & Plomin, R. (2006). Environmental risk and young children's cognitive and behavioral development. *International Journal of Behavioral Development, 30,* 55–66.

Posner, M., & Rothbart, M (2000). Developing mechanisms of self-regulation. *Development and Psychopathology, 21,* 427–441.

Robin, M., Josse, D., & Tourrette, C. (1988). Mother-twin interaction during early childhood. *Acta Geneticae Medicae et Gemellologiae, 37,* 151–159.

Rothbart, M. (1989). Temperament and development. In G. Kohnstamm, J. Bates, & M. Rothbart (Eds.), *Temperament in childhood* (pp. 187–248). Chichester, England: Wiley.

Rothbart, M. K. (1981). Measurement of temperament in infancy. *Child Development, 52,* 569–578.

Rothbart, M. K. (1986). Longitudinal observation of infant temperament. *Developmental Psychology, 22,* 356–365.

Rothbart, M., & Bates, J. (2006). Temperament. In W. Damon, R. Lerner, & N. Eisenberg (Eds.), *Handbook of Child Psychology: Vol. 3, Social, emotional, and personality development* (6th ed., pp. 99–166). New York: Wiley.

Rothbart, M. K., & Derryberry, D. (1981). Development of individual differences in temperament. In M. E. Lamb & A. L. Brown (Eds.), *Advances in developmental psychology, Vol. 1* (pp. 37–86). Hillsdale, NJ: Erlbaum.

Rothbart, M. K., Derryberry, D., & Hershey, K. (2000). Stability of temperament in childhood: Laboratory infant assessment to parent report at seven years. In V. J. Molfese & D. L. Molfese (Eds.), *Temperament and personality development across the life span* (pp. 85–119). Mahwah, NJ: Erlbaum.

Salley, B., & Dixon, W. (2007). Temperament and joint attention predictors of language development. *Merrill Palmer Quarterly, 53,* 131–154.

Sanson, A., Oberklaid, F., Pedlow, R., & Prior, M. (1991). Risk indicators: Assessment of infancy predictors of preschool behavioral maladjustment. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 32,* 609–626.

Shipley, W. C. (1991). *Shipley Institute of Living Scale.* Los Angeles: Western Psychological Services.

Siegel, L. (1983). Correction for prematurity and its consequences for the assessment of the very low birth weight infant. *Child Development, 54,* 1176–1188.

Smith, K. E., Landry, S. H., & Swank, P. R. (2000). The influence of early patterns of positive parenting on children's preschool outcomes. *Early Education & Development, 11,* 147–169.

Thatcher, R. W. (1994). Cyclical cortical reorganization: Origins of human cognitive development. In G. Dawson & K. W. Fischer (Eds.), *Human behavior and the developing brain* (pp. 232–266). New York: Guilford Press.

Thomas, A., & Chess, S. (1977). *Temperament and development.* New York: Brunner/Mazel.

Thorpe, J., Golding, J., MacGillivray, I., & Greenwood, R. (1991). Comparison of prevalence of depression in mothers of twins and mothers of singletons. *British Medical Journal, 302,* 875–878.

Veldman, D. J., & Worsham, M. (1983). Types of student classroom behavior. *Journal of Educational Research, 76,* 204–209.

Weizman, Z. O., & Snow, C. E. (2001). Lexical input as related to children's vocabulary acquisition: Effects of sophisticated exposure and support for meaning. *Developmental Psychology, 37,* 265–279.

West, A. E., & Newman, D. L. (2003). Worried and blue: Mild parental anxiety and depression in relation to development of young children's temperament and behavior problems. *Parenting: Science and Practice, 3,* 133–154.

Wilson, S. L., & Cradock, M. (2004). Review: Accounting for prematurity in developmental assessment and the use of age-adjusted scores. *Journal of Pediatric Psychology, 29,* 641–649

Windle, M., & Lerner, R. M. (1986). Reassessing the dimensions of temperamental individuality across the life span: The Revised Dimensions of Temperament Survey (DOTS-R). *Journal of Adolescent Research, 1,* 213–229.

Wolfe, C., & Bell, M. (2007). The integration of cognition and emotion during infancy and early childhood: Regulatory processes associated with the development of working memory. *Brain and Cognition, 65,* 3–13.

Zeanah, C. H., Keener, M. A., & Anders, T. F. (1986). Developing perceptions of temperament and their relation to mother and infant behavior. *Journal of Child Psychology and Psychiatry, 27,* 499–512.